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# Report of the Commission of Inquiry on Aluminum Wiring

Part 1

J. Tuzo Wilson, *Commissioner*



December  
1978



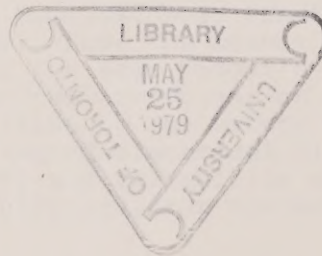
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# Report of the Commission of Inquiry on Aluminum Wiring

Part 1

J. Tuzo Wilson, *Commissioner*



Queen's Printer for Ontario  
December 1978

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Inquiry on  
Aluminum Wiring

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The Honourable Pauline M. McGibbon,  
Lieutenant-Governor of Ontario

Your Honour:

I, the Commissioner, appointed by you on April 6, 1977, have the honour to submit respectfully for Your Honour's consideration my report on the investigation upon all matters relating to the safety and reliability of aluminum-wired electrical circuits, relative to the safety and reliability of copper-wired electrical circuits, for residential use.


Yours sincerely,

*J. Tuzo Wilson*

J. Tuzo Wilson  
Commissioner

September 30, 1978





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Ontario

Executive Council

O.C. 1029/77

Copy of an Order-in-Council approved by  
Her Honour the Lieutenant Governor, dated the 6th  
day of April, A.D. 1977.

The Committee of Council have had under  
consideration the report of the Honourable the  
Minister of Consumer and Commercial Relations,  
wherein he states that,

WHEREAS this Government recognizes that  
there is some question in the public mind as to  
the reliability and safety of aluminum wired  
electrical circuits for residential use;

AND WHEREAS there appears to be a lack  
of consensus amongst the standard setting bodies,  
manufacturing industries, installers, electrical  
inspection agencies and consumer organizations as  
to the reliability and safety of aluminum wired  
electrical circuits for residential use;

AND WHEREAS in order to resolve the  
conflict of views and to ensure that the public's  
interest is best served, it is thought fit to  
refer these matters to an inquiry instituted  
pursuant to the provisions of The Public Inquiries  
Act, 1971, s.o. 1971, Chapter 49;

The Honourable the Minister of Consumer and Commercial Relations therefore recommends that pursuant to the provisions of The Public Inquiries Act, 1971, s.o. 1971, Chapter 49, a Commission be issued appointing

Dr. John Tuzo Wilson,  
Toronto

as Commissioner, empowered and instructed:

- (1) to investigate all matters relating to the safety and reliability of aluminum wired electrical circuits for residential use, relative to the safety and reliability of copper wired electrical circuits for residential use;
- (2) to hold public hearings to enable groups and organizations, individual citizens and representatives of industry to present evidence and other pertinent information on the subject;
- (3) to make appropriate recommendations, if warranted, on any measures that should be taken by the Government of Ontario, by other levels of Government, by the general public and by the industry.

The Honourable the Minister of Consumer and Commercial Relations further recommends that the said Commissioner shall have the power of summoning any person and requiring such person to give evidence

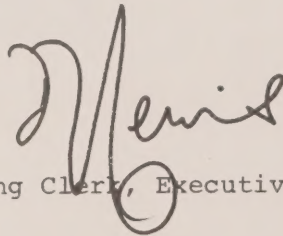


on oath and to produce such documents and things as the Commissioner deems requisite for the full investigation of the matters to be examined;

And the Honourable the Minister of Consumer and Commercial Relations further recommends that all Government Ministries, boards, agencies and commissions shall assist the said Commissioner to the fullest extent in order that he may carry out his duties and functions and that he shall have the power and authority to engage counsel, expert technical advisors, investigators and other staff as he deems proper at rates of remuneration and reimbursement to be approved by the Management Board of Cabinet.

The Committee of Council concur in the recommendations of the Honourable the Minister of Consumer and Commercial Relations and advise that the same be acted on.

Certified,

A handwritten signature in dark ink, appearing to read "M. Lewis", is written over the typed name "M. Lewis". The signature is fluid and cursive.

M. Lewis  
Acting Clerk, Executive Council.



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## 1.1 Introduction, Scope of Report, and Acknowledgements

The Commission of Inquiry on Aluminum Wiring was issued in accordance with Order-in-Council 1029/77, dated April 6, 1977, and a staff was assembled.

The opening hearing took place in Toronto on June 6, 1977. Status was requested by and given to counsel and witnesses — a total of nine — because they, as either individuals or representatives of organizations, demonstrated a direct and substantial interest in the Commission's subject of inquiry. The granting of status meant that these persons would be notified of all hearings and that they would be able to examine witnesses. In addition, the Commission paid the expenses to attend the hearings, at their request, for representatives of two consumer groups who had been given status.

The Commission held fifty-eight sessions, at which eighty-two witnesses gave evidence and were examined, and 250 exhibits were entered. Every person who asked to be heard was heard and everyone whom anyone wished to have called was called. No one was denied an opportunity to examine witnesses either directly or through counsel.

The Commission endeavoured to investigate by all suitable means all matters within Ontario as instructed by its terms of reference. It widely advertised the hearings and held hearings in all those places in Ontario where sufficient interest was expressed: Toronto, Brampton, Scarborough, and Ottawa. The help of municipal authorities in making arrangements for the hearings is acknowledged. The Commission investigated the use of aluminum wiring in other parts of Canada and abroad to the extent necessary to insure that advantage was taken of experience elsewhere. It noted that regulations and practices differ in every jurisdiction. Thus conclusions applicable elsewhere cannot be applied directly to the situation in Ontario without caution and modification, although some general lessons may be learned.

The Commission visited several laboratories and groups of experts and thanks all the people concerned for the help and information that they provided (see Section 1.7). The co-operation of the United States Consumer Product Safety Commission in providing the Commission with technical information is gratefully acknowledged. The Commission acknowledges with thanks the help of the librarians of Ontario Hydro, the Canadian Standards Association, the University of Toronto, Aluminum Company of Canada, Ltd. Research Centre (Kingston, Ontario), and of the Canada Institute for Scientific and Technical Information (Ottawa, Ontario), in preparing the bibliography and other matters.

In order to express the findings with adequate precision, part of the report has necessarily been written in technical language, and there is a technical bibliography sufficiently complete to serve all practical purposes. For the general reader, the recommendations, summaries, and a glossary of terms have been written in standard English.

The Commission wishes to acknowledge the help provided by the witnesses. Without the information that they supplied, little would have been accomplished. The Commission gratefully recognizes that many witnesses travelled considerable distances, some attended regularly, and others recalled matters that had grieved or affected them deeply. Some of the witnesses, and many other parties listed in the report by name or by category, assisted the Commission by providing reports and publications or by answering questionnaires and inquiries. The co-operation of all is much appreciated. The press and the radio and television stations assisted the Commission by providing coverage in a co-operative and helpful manner.

The legal powers of a Commission of Public Inquiry are limited. Much depends upon the goodwill and honesty of the participants. It is a fitting tribute to the co-operation and courtesy of witnesses and counsel alike to record that at all times the Commissioner found it a pleasure to conduct the hearings.

The Commission is indebted to three Ministers of Consumer and Commercial Relations, the Honourable S. Handleman, the Honourable L. Grossman, and the Honourable F. Drea, and to members of their staff, especially Messrs. R.J. Butler and H.Y. Yoneyama, for their help during the organization of the Commission and the presentation of this report. Other administrative assistance was provided by the Ministry of the Attorney General, especially by Messrs. B.W. McLoughlin and P.W. Clendinneng; by the Queen's Printer for Ontario, through Mr. R. Noll; and by the Ontario Science Centre, Don Mills.

The Commission was fortunate to obtain so excellent a staff and would like to thank all of its members, without exception, for their hard and able work. Their names and positions are listed in Section 1.2. Since all were specialists and in much demand, it was mutually convenient — and economical for the Commission — that each of them be employed for only short periods or on an intermittent, part-time basis. Only Mrs. Joanne Kovach worked continuously for most of the duration of the Commission's activities.



## 1.2 Commission Staff

<i>Commissioner</i>	Dr. J. Tuzo Wilson, C.C., O.B.E., Ph.D., P.Eng., F.R.S. Director General, Ontario Science Centre, Don Mills
<i>Counsel</i> (until October 14, 1977)	Mr. Justice W.J. Anderson, LL.B., Q.C.
(after October 14, 1977)	Mr. William Liber, Q.C.
<i>Technical Staff</i>	Professor K.D. Srivastava, Ph.D., P.Eng. Chairman, Department of Electrical Engineering, University of Waterloo, Waterloo  Professor G.C. Craig, Ph.D., P.Eng. Chairman, Centre for the Study of Materials, University of Toronto, Toronto  Mr. D.A. Sharkey, B.A.Sc., P.Eng., Journeyman Electrician (Ireland and U.K.) General Manager, K-Tek Electro-Services Limited, Toronto  Professor Allan E. Paull, Ph.D. Institute for Applied Statistics, University of Toronto, Toronto
<i>Clerk Assistant to Counsel</i>	Miss Alison Manzer, B.Sc., LL.B.
<i>Executive Secretary</i> (until June 27, 1977)	Mr. Donald V. Fowke, B.E., S.M., P.Eng., F.M.C.
(after June 27, 1977)	Mrs. Joanne Kovach
<i>Executive Director</i> (until June 27, 1977)	Mr. B.V. Marmash, B.A., M.B.A., C.M.C.
<i>Editor</i>	Miss Mary E. Willmot, B.A., B.Sc.
<i>Research Assistant</i> (until June 27, 1977)	Miss Marilyn Jones, B.A., C.M.C.
<i>Bibliographer</i>	Miss Judy Griesbach
<i>Secretary</i>	Mrs. Judy Nicholson

## 1.3 Outline of Procedure for Public Inquiries

During the organizational stage of the Commission of Inquiry on Aluminum Wiring, rules of procedure were drafted to supplement the provisions of the Public Inquiries Act, R.S.O. 1971, Chapter 49. These rules of procedure provided that

- Status to examine the witnesses would be given to a person who could demonstrate a substantial and direct interest in the subject matter of this Commission.
- Any person who wished to give evidence before a hearing of the Commission would be required to file in advance a written statement indicating the nature of the evidence that would be given.
- Opinion evidence would be given by a duly qualified expert.
- Hearings would be held at such times, in such places, and pursuant to such notice as the Commissioner, in his discretion, decided.

## 1.4 Interpretations of the Terms of Reference

The Commission of Inquiry on Aluminum Wiring was given the power to investigate matters concerning aluminum-wired electric circuits for residential use, to hold public hearings for the purpose of gathering evidence, and to make appropriate recommendations at the conclusion of the investigation.

The Commissioner was not given power to take individual action, regardless of his findings, nor to investigate matters serving to establish the liability, if any, of any party or parties involved in the controversy.

The investigation was confined to an evaluation of the comparative reliability and safety of aluminum-wired electric circuits and similar copper-wired circuits for residential use. The residential circuit was defined, for the Commission's purposes, as a circuit that commences at the connection of the house wiring to the panelboard. This meant that the panelboard would be examined to determine its performance only with an aluminum-wire, in comparison with, a copper-wire connection. Although the panelboard's internal workings, which were similar for the two conductors, were considered to be beyond the scope of this Commission, a number of witnesses reported failures related to the design and construction of panelboards.

The terms of reference were defined further to require a comparative evaluation of aluminum-wired circuits and of copper-wired circuits. The necessity of restricting the inquiry to residential installations is evident from the wording of the Order-in-Council that established the Commission.

## 1.5 Schedule of Hearings

<i>Date of Hearing</i>	<i>Volume*</i>	<i>Location</i>	<i>Morning/Afternoon/ Evening Hearings</i>
June 6, 1977	1	Toronto	Morning
June 27, 1977	2	Toronto	Afternoon
June 28, 1977	3	Toronto	Morning/Afternoon
August 22, 1977	4	Toronto	Morning/Afternoon
August 23, 1977	5	Toronto	Morning
August 24, 1977	6	Toronto	Morning
August 24, 1977	7	Toronto	Evening
August 25, 1977	8	Toronto	Morning
August 29, 1977	9	Toronto	Morning/Afternoon
August 30, 1977	10	Toronto	Morning/Afternoon
August 31, 1977	11	Toronto	Morning/Afternoon
October 11, 1977	12	Bramalea	Afternoon/Evening
October 12, 1977	13	Bramalea	Afternoon/Evening
October 13, 1977	14	Bramalea	Evening
October 17, 1977	15	Ottawa	Afternoon/Evening
October 18, 1977	16	Ottawa	Afternoon/Evening
November 17, 1977	17	Scarborough	Afternoon/Evening
November 18, 1977	18	Scarborough	Afternoon/Evening
December 14, 1977	19	Toronto	Afternoon/Evening
December 15, 1977	20	Toronto	Morning/Afternoon
December 16, 1977	21	Toronto	Morning/Afternoon
January 9, 1978	22	Toronto	Morning/Afternoon
January 10, 1978	23	Toronto	Morning/Afternoon
January 16, 1978	24	Toronto	Morning/Afternoon
January 17, 1978	25	Toronto	Morning/Afternoon
January 18, 1978	26	Toronto	Morning/Afternoon
February 6, 1978	27	Toronto	Morning/Afternoon
February 7, 1978	28	Toronto	Morning/Afternoon
February 8, 1978	29	Toronto	Morning/Afternoon
February 13, 1978	30	Toronto	Morning/Afternoon
February 14, 1978	31	Toronto	Afternoon
February 15, 1978	32	Toronto	Morning/Afternoon
March 2, 1978	33	Toronto	Morning/Afternoon

Total number of hearing days: 32

Total number of hearing sessions: 58

\*The volume of the transcript of the particular hearing held by the Commission.

## 1.6 Witnesses at the Commission Hearings

<i>Date of Hearing</i>	<i>Witness</i>
June 6, 1977 (1)*	Preliminary hearing to determine parties having status with Commission.
June 27, 1977 (2)	Dr. P.D. McTaggart-Cowan retired physicist, Bracebridge
June 28, 1977 (3)	Mr. D. Bland Alcan Canada Products Limited, Toronto  Dr. U. Franklin Department of Metallurgy and Materials Science, University of Toronto, Toronto
August 22, 1977 (4)	Mr. J.E. Kean Managing Director, Canadian Standards Association, Rexdale  Mr. W.G. Hoyle Senior Research Officer, National Research Council of Canada, Ottawa  Mr. R.O. Lambert Chief of Electrical Inspection, Manitoba Hydro, Winnipeg, Manitoba  Mr. D.M. Dymond Director, Standards Division, Canadian Standards Association, Rexdale
August 23, 1977 (5)	Mr. D.M. Dymond Director, Standards Division, Canadian Standards Association, Rexdale
August 24, 1977 (6)	Mr. D.M. Dymond Director, Standards Division, Canadian Standards Association, Rexdale
August 24, 1977 (7)	Mr. D.M. Dymond Director, Standards Division, Canadian Standards Association, Rexdale
August 25, 1977 (8)	Mr. D.M. Dymond Director, Standards Division, Canadian Standards Association, Rexdale
August 29, 1977 (9)	Mr. J.A. Dicker Manager, Electrical Inspection Department, Ontario Hydro, Toronto  Mr. R.L. Hicks Engineer, W.P. Dobson Research Laboratory, Ontario Hydro, Toronto
August 30, 1977 (10)	Mr. J.A. Dicker Manager, Electrical Inspection Department, Ontario Hydro, Toronto  Mr. R.L. Hicks Engineer, W.P. Dobson Research Laboratory, Ontario Hydro, Toronto
August 31, 1977 (11)	Mr. R.L. Hicks Engineer, W.P. Dobson Research Laboratory, Ontario Hydro, Toronto  Mr. J.A. Dicker Manager, Electrical Inspection Department, Ontario Hydro, Toronto

\*The volume of the transcript of the Commission's proceedings that includes the particular hearing.



<i>Date of Hearing</i>	<i>Witness</i>
October 11, 1977 (12)	Mr. R. Weir Chief Fire Prevention Officer, Brampton Fire Department, Brampton  Mr. A.L. Oliphant Deputy Fire Chief, Mississauga Fire Department, Mississauga  Mrs. N. Morton home-owner, Rexdale  Mr. G. Hancock home-owner, Mississauga  Mr. W.L. Upcott home-owner, Brampton  Mr. P.T. Boychuk home-owner, Bramalea  Mr. L. Halbach Co-ordinator, Brampton Area, Aluminum Wiring Home Owners Association, Brampton  Mr. E. Pfeiffer home-owner, Oakville  Mrs. M. Wilkinson home-owner, Mississauga  Mr. T. Wilkinson home-owner, Mississauga  Mr. L. Mann home-owner, Bramalea  Mr. R.L. Kubas home-owner, Bramalea
October 12, 1977 (13)	Mrs. V. Talbot home-owner, Brampton  Mrs. S. Carnegie home-owner, Milton  Mr. G. Heighington co-founder of Aluminum Wiring Home Owners Association, Brampton  Mr. J. Murphy co-founder of Aluminum Wiring Home Owners Association, Brampton
October 13, 1977 (14)	Mr. P.C. Ruse home-owner, Milton  Mrs. J. Pozarychi home-owner, Mississauga  Mr. W.L. Bates home-owner, Mississauga  Mrs. D. Yeo home-owner, Milton
October 17, 1977 (15)	Mr. B. Jerabek founder and President of Concerned Consumers Foundation Inc., Ottawa
October 18, 1977 (16)	Mr. J.E. Morey Supervisory Electrical Inspector, Ontario Hydro, Ottawa

<i>Date of Hearing</i>	<i>Witness</i>
	Mr. B. Jerabek founder and President of Concerned Consumers Foundation Inc., Ottawa
	Mr. G. St. Aubin Building Inspector, Township of March, Kanata
	Mrs. B. Stewart Deputy Reeve, Township of Gloucester, Ottawa
	Mr. A. Sowards member of Aluminum Wiring Committee, Kanata
	Mr. K.A. Sharp Journeyman Inspector, Ontario Hydro, Ottawa
November 17, 1977 (17)	Mrs. J. Trimmer Controller, Borough of Scarborough, Scarborough
	Mr. A. Ballantyne Wiring Instructor, Scarborough High School, Scarborough
	Mr. H.N. Nelson home-owner, Mississauga
	Mr. A. Bissember home-owner, Willowdale
	Mr. A.W. Masterton home-owner, Unionville
	Mr. R.G. Chad home-owner, Scarborough
November 18, 1977 (18)	Mrs. B. MacPherson home-owner, Scarborough
	Mr. D. Clark home-owner, Scarborough
	Mrs. M. Lorenz home-owner, Scarborough
	Mrs. S. Black home-owner, Don Mills
	Mrs. A. Sherer home-owner, Willowdale
	Mr. M. Parker home-owner, Scarborough
December 14, 1977 (19)	Mr. D. Armour President, Electrical and Electronic Manufacturers Association of Canada, Toronto
	Mr. D.K. Venus Manager, Metric Co-ordination, Electrical and Electronic Manufacturers Association of Canada, Toronto
	Mr. R.E. Stopps Manager, Standards and Technical Services, Electrical and Electronic Manufacturers Association of Canada, Toronto
	Mr. J. Murphy co-founder of Aluminum Wiring Home Owners Association, Brampton

<i>Date of Hearing</i>	<i>Witness</i>
	Mr. G. Heighington co-founder of Aluminum Wiring Home Owners Association, Brampton
December 15, 1977 (20)	Mr. R.T. Whiteford Supervising Electrical Inspector, Ontario Hydro, Brampton
December 16, 1977 (21)	Mr. L. Stoch Electrical Inspection Superintendent, Ontario Hydro, Willowdale  Mr. R.T. Whiteford Supervising Electrical Inspector, Ontario Hydro, Brampton
January 9, 1978 (22)	Mr. L. Stoch Electrical Inspection Superintendent, Ontario Hydro, Willowdale  Mr. D. Martyniuk Danmar Electric, Toronto
January 10, 1978 (23)	Mr. D. Armour President, Electrical and Electronic Manufacturers Association of Canada, Toronto  Mr. D.K. Venus Manager, Metric Co-ordination, Electrical and Electronic Manufacturers Association of Canada, Toronto  Mr. R.E. Stopps Manager, Standards and Technical Services, Electrical and Electronic Manufacturers Association of Canada, Toronto  Mr. J. Parik Electrical Engineer, Ministry of Government Services, Toronto
January 16, 1978 (24)	Mr. D.M. Dymond Director, Standards Division, Canadian Standards Association, Rexdale
January 17, 1978 (25)	Mr. R.L. Hicks Engineer, W.P. Dobson Research Laboratory, Ontario Hydro, Toronto
January 18, 1978 (26)	Mr. A. Zdanowicz Manager, Technical Services Division, Ontario Ministry of Housing, Toronto  Mr. W. Howard Program Consultant, Program Resources Branch, Ontario Ministry of Colleges and Universities, Toronto  Mr. T. Jeffree Supervisor, Training Information, Ontario Ministry of Colleges and Universities, Toronto
February 6, 1978 (27)	Mr. J.A. Hirschfield Aluminum Company of Canada, Ltd., Research Centre, Kingston  Mr. K.J. Smith Aluminum Company of Canada, Ltd., Research Centre, Kingston  Mr. G.D. Papazian Alcan Canada Products Limited, Toronto  Dr. R.S. Timsit Aluminum Company of Canada, Ltd., Research Centre, Kingston

<i>Date of Hearing</i>	<i>Witness</i>
February 7, 1978 (28)	Mr. J.A. Dicker Manager, Electrical Inspection Department, Ontario Hydro, Toronto  Mr. F.P. Kehoe Supervising Electrical Inspector, Ontario Hydro, London  Mr. R.J. Burgess Program Chairman, Electric League of London, London  Mr. J.P. Flynn Electric League of London, London
February 8, 1978 (29)	Dr. M. Léger Engineer, Metallurgy Section, W.P. Dobson Research Laboratory, Ontario Hydro, Toronto  Mr. J.A. Dicker Manager, Electrical Inspection Department, Ontario Hydro, Toronto  Mr. A.C. Williams Deputy Fire Marshal, Ontario Fire Marshal's Office, Toronto
February 13, 1978 (30)	Mr. M.A. Lamothe Manager, Research and Development, Smith & Stone Limited, Georgetown  Mr. R. Patterson Canadian General Electric Company Limited, Toronto
February 14, 1978 (31)	Mr. C.T. Fryberger Consulting Engineer, Thomas & Betts Limited, Elizabeth, New Jersey, U.S.A.  Mr. D.G. Holmes Circle F (Canada) Ltd., Pickering
February 15, 1978 (32)	Mr. T.W. Creaghan Vice-President and General Manager, Smith & Stone Limited, Georgetown  Mr. R. Hoffman Product Engineer, AMP Incorporated, Harrisburg, Pennsylvania, U.S.A.  Mr. J. Hardman Assistant Director, Product Approvals Division, AMP Incorporated, Harrisburg, Pennsylvania, U.S.A.  Mr. D. Donaldson Market Manager, AMP of Canada Limited, Markham  Mr. W. Briggs Market Sales Manager, AMP of Canada Limited, Markham  Dr. P.D. McTaggart-Cowan retired physicist, Bracebridge  Mr. B. Keogh Reeve, Village of Tottenham, Tottenham  Mr. J. Belford Works Superintendent, Village of Tottenham, Tottenham
March 2, 1978 (33)	Mr. M. Smith Fire Chief, Town of Markham, Markham

*Date of Hearing*

*Witness*

Dr. M. Braunovic

Institute of Research, Hydro Quebec, Varennes, Quebec

Mr. K. Cross

Alcan Canada Products Limited, Toronto

Mr. P. Campbell

Chief Fire Prevention Officer, Town of Oakville, Oakville

Mr. D.G. Wood

Manager, Loss Control, Insurers' Advisory Organization, Toronto

Mr. J.A. Dicker

Manager, Electrical Inspection Department, Ontario Hydro, Toronto

Dr. M. Léger

Engineer, Metallurgy Section, W.P. Dobson Research Laboratory, Ontario Hydro, Toronto

Total number of witnesses: 82

Total number of hearing days: 32

Total number of hearing sessions: 58



## 1.7 Technical Laboratories Visited by the Commissioner and Staff

<i>Organization</i>	<i>Date</i>
<b>Canada</b>	
Canadian Standards Association Rexdale, Ontario	July 22, 1977
W.P. Dobson Research Laboratory, Ontario Hydro Toronto, Ontario	August 16, 1977
Aluminum Company of Canada, Ltd., Research Centre Kingston, Ontario	September 15, 1977
Institute of Research, Hydro Quebec Varenes, Quebec	September 16, 1977
Concerned Consumers Foundation Inc. B. Jerabek Laboratory Ottawa, Ontario	September 17, 1977
<b>United States</b>	
Underwriters' Laboratories, Inc. Melville, New York	November 7, 1977
Bell Laboratories Murray Hill, New Jersey	November 8, 1977
*Bell Laboratories Murray Hill, New Jersey	April 27, 1978
<b>**India</b>	December 20, 22, 23, and 31, 1977
Ministry of Public Works New Delhi, India	
Indian Standards Institution New Delhi, India	
Directorate General of Supplies and Disposals New Delhi, India	
Directorate General of Technical Development New Delhi, India	
Government of India Overseas Communication Centre New Delhi, India	

\*Dr. J. Tuzo Wilson, Commissioner, made these visits alone and at no expense to the Commission for travel.

\*\*Dr. K. D. Srivastava made these visits alone and at no expense to the Commission for travel.

*Organization*

*Date*

**United Kingdom**

\* Electrical Research Association  
Leatherhead, England

February 1, 1978

**Japan**

\* Technical Standards Division Japan Electrical Association,  
Japanese National Committee for International Electro-  
technical Commission, Technical Committee 64  
Tokyo, Japan

March 15, 1978

\*Dr. J. Tuzo Wilson, Commissioner, made these visits alone and at no expense to the Commission for travel.

## 1.8 Commissioner's Observations

Part 2 of this report summarizes the evidence heard and read by this Commission. Much of the evidence was of a technical nature and Section 2.4 gives in standard English a summary of the main conclusions.

Section 1.8 outlines some of the premises and conclusions that formed the foundation for the Commission's recommendations in Section 1.9.

### 1.8.1 Variations in Safety and Reliability

The first subjects that the Order-in-Council directed the Commission to consider were the reliability and the safety of aluminum-wired branch circuits for residential use, relative to the reliability and safety of copper-wired circuits for residential use.

Section 2.8 shows that few accurate statistical data exist on these subjects. To the extent that the inadequate data do show a trend, they indicate that aluminum wiring has been less reliable than copper wiring.

Other pertinent material on the aspect of reliability, in the form of judgements and opinions, is more abundant, but even less secure. Points of view have been expressed that range from one that regards aluminum, as used in the past in residential branch circuits, as much less reliable than, though nearly as good as, copper, to even the rare expression that, under some circumstances, aluminum performs better than copper. Different witnesses at the hearings, as well as publications, have chosen some or other pieces of this uncertain evidence to support their views.

The evidence regarding safety is even more sparse, dubious, and uncertain.

The Commission has considered the diversity of judgements and views and is of the opinion that it is real and not merely the result of bias; in other words, the degree of reliability and safety of aluminum wiring relative to copper has differed with time, place, and circumstance. These variations in points of view will now be considered.

*a. Variations with Time.* The variations with time fall into three stages, before 1965, from 1965 to 1976, and through 1977 and 1978.

During the first stage, few houses were wired with aluminum. The Commission heard evidence that among the few so wired were seventy-five houses in Arvida, Quebec. The aluminum wiring, which was installed in 1948, was inspected after five years and again after twenty-eight years, and found to be performing reliably and without failures. There is good reason to suppose that the builder was much interested in this test of aluminum wiring and demanded superior workmanship but, by today's standards, the materials were inferior. The receptacles, which were of an out-of-date design and pre-CO/ALR type, would not now be permitted for use with aluminum, and the conductors were presumably of fully hard EC-grade aluminum. Since 1967 half-hard EC-grade aluminum has been used. Another example of the early use of residential aluminum wiring is the houses in Kitimat, British Columbia, which were wired in 1953. No evidence was given of any problems in these houses.

During this period, the responsible authorities, particularly in the United States, not only monitored the few installations but also conducted successful laboratory tests of aluminum wiring. The standards of the tests were not of those demanded today, and the technical input into the tests' design was not so complete as it might have been, but the loads placed upon household wiring were not so great at that time as they are now, and knowledge of terminations with aluminum wiring was slight.

Thus by 1965 the use of aluminum wiring had been considered and, though a few warning observations had been made, both residential use and laboratory tests seemed to suggest that aluminum wiring was safe and reliable for use in residential systems. Its use had already become standard in transmission lines.

The second stage began in 1965 when copper became expensive and hard to obtain and, at the same time, the building industry was booming. People demanded housing. Aluminum appeared to be an acceptable substitute for copper, not because it was thought to be better, but because it was available and cheaper. From 1965 to 1974 it was substituted for copper at a steadily increasing rate. Throughout a period of similar length, but delayed by two or three years — that is, the period from 1967 to 1976 — reports of problems with aluminum wiring mounted. During this period, the evidence suggests that aluminum wiring was less reliable and hence, presumably, less safe than copper (although evidence for the latter is not clear).

Since this change in opinion was unexpected, it took some time for householders, builders, and authorities alike to realize that the problems were real, to discover how widespread they were, and to define the precise causes. It is easy now to say that aluminum should never have been allowed, but at the time knowledge was lacking and neither builders nor householders were willing to wait until copper again became cheap and available.

Starting in 1967 and throughout this period of growing awareness, the responsible authorities and industry undertook a programme of research and investigation on the subject. Committees of experts were established, which recommended such improvements as better aluminum alloys and the CO/ALR devices, but the authorities did not advertise what they were doing. Presumably this reticence was because their earlier experience had not prepared them for the problems that had begun to surface. At first the authorities did not fully understand the urgency of the situation and, until they had made their investigations and tests, they did not have any immediate remedies to suggest.

By 1975 the work of the Canadian Standards Association, of Ontario Hydro, and of United States organizations had disclosed some of the causes of troubles. Better devices and materials for use with aluminum were becoming available, and there was a greater knowledge of precautions necessary when working with aluminum wire. As Sections 2.5, 2.6, and 2.7 show, the matter was complex, but investigations were extensive and are still continuing.

Meanwhile the problems had attracted the concern of the public and the attention of the press, radio, and television. In 1975 consumers formed two groups in Ottawa and, in 1977, one association in Brampton. The publicity served three very useful purposes. It alerted householders to possible dangers. It spurred them and the authorities, who by now knew better what to do, into taking appropriate actions. It provided a monitor to gauge the extent of the difficulties.

Since 1974 a decline in demand for housing and an easing of the price of copper have reduced activity in building and in the use of aluminum wiring. The causes of earlier problems are better understood. New procedures and better devices are available. Most of the householders who had had troubles have taken corrective measures.

Certain manufacturers supplied the Commission with precise details of the sale in Canada of 1,178,594 CO/ALR receptacles between July 1975 and September 1978 and an estimate that, if sales by other manufacturers are included, a total of about 1,500,000 of the new CO/ALR receptacles have been sold. Presumably, because of the decline in the number of houses being built, most of these receptacles were used as replacements. These CO/ALR receptacles were designed to provide greater safety with aluminum as well as copper wiring.

Ontario Hydro, through its inspectors, has taken vigorous action in response to the public's request for information. In various cities they established a free *hot-line* telephone service to deal with householders' problems and offer advice; they made free inspections of houses wired with aluminum; they changed faulty devices and terminations; and they warned electrical contractors about the need for very good workmanship with aluminum wiring. Ontario Hydro also prepared a leaflet, which informed householders of danger signals, and offered it to local utilities for distribution.

The third stage covers 1977 and 1978. During this period, the Commission advertised widely, held fifty-eight hearings, and listened to accounts of many unfortunate events, but the proceedings gave the impression of dealing largely with the past. The events described had, with few exceptions, occurred earlier.

Of the eighty-two witnesses at the Commission's hearings, four may be regarded as representatives of three consumers' organizations; twenty-six others were concerned householders. The Commission is grateful to them for their evidence and has considered very carefully and analysed



it in Section 2.7. Serious as were some of the events these witnesses and others reported to the Commission, it does not seem that only thirty witnesses out of 250,000 householders in Ontario indicates widespread concern, especially since one householders' organization claimed to have over 500 family memberships, mostly in the areas where hearings were held. Furthermore, the fact that concern is not great or at least not widespread is indicated by the attendance at the hearings: a core group of only about two dozen persons — representatives of parties with status and their counsel — attended all of the hearings; witnesses came when they were called; at no time did a large crowd attend; and at most of the hearings, few or no members of the public were present.

The analysis of these witnesses' evidence, as well as that of various technical experts, is well covered in Part 2. It suggests that little trouble arose where workmanship and material were good in the first place, and that problems largely disappeared where sound corrective action was taken. This does not mean that no fires have occurred or that none will occur in future. Unfortunately many fires do occur but, as Section 2.8 shows, some are due to failures in copper wiring and most are not of any electric origin. Section 2.8 also shows that of all fires less than ten per cent are from electric causes and of these only a small fraction are due to aluminum residential wiring.

Naturally, during the hearings, the Commission and many involved in the work watched anxiously for fresh incidents due to aluminum wiring, but fortunately few were forthcoming.

The evidence of K. Sharp, an inspector for Ontario Hydro in the Ottawa region, shows the great decline in occurrences and reports of problems. The diary of his work, which was entered as Exhibit 122-A and 122-B, shows that during fifteen months from October 1974 to December 1975, Mr. Sharp replaced 263 receptacles — of which seventy-one had become overheated — but only six during the whole of 1976, and few since.

In August 1978, when the final pages of this report were being written, a flurry of publicity served to confirm the earlier evidence that the lack of recent incidents and diminishing public interest shown during the hearings was continuing. The publicity arose from the release of Report 78-92-K of Ontario Hydro Research Division, entitled *Progress Report — Fire Initiation of Failing Electrical Receptacles*. The report was authorized on and dated February 28, 1978, and completed in April when Ontario Hydro sent a copy to the Commission. Like all other internal documents of Ontario Hydro, it was stamped "Not for Publication," which seems to be unnecessary since there is nothing secret about it. For some bureaucratic reason, this stamp is applied to all internal Ontario Hydro reports, only a few of which need it.

The report describes a laboratory test in which a deliberate attempt was made to discover under what extreme conditions aluminum-wired devices could start a fire and it demonstrated the difficulty of doing this. The receptacle used was of a type no longer approved and it had already failed once. Its junction box was surrounded by wood fibre and the cover plate was covered by a thick cotton blanket. The receptacle was shaken to disturb it and, even so, it took 16 hours at a maximum current of 15 amperes to cause ignition. The entire summary as given in the report follows:

Preliminary results from fire initiation experiments using failing aluminum-wired push-in receptacles indicate that a cellulose fibre-wood panelling construction created a much greater fire hazard than the more common combination of gypsum board and mineral fibre insulation.

The test did nothing to show the relative safety of aluminum and copper wire because copper was not tested. The fact that so much publicity was given to a single laboratory test and not to any real problem suggests that no major incidents or fires had occurred recently. On its release the report and comments made about it were given widespread coverage in leading newspapers, on radio, and on at least one national television network.

Apart from reporters asking for a statement, the Commission received only one inquiry, a telephone call asking when its report would be published. Surprised by this lack of public interest, the Commission asked Ontario Hydro what inquiries they had received. The Electrical Inspection Department of Ontario Hydro reported that, in the week following this extensive publicity, its sixteen offices (including the Brampton hot line) had had forty calls, of which most had been for information only, and that seventeen inspections had been made. Only one inspection disclosed any fault. This was a failure due to a mistake made in a panelboard by an electrician in repairing a



fuse block attached to a copper-wired circuit. The Commission considers that this recent information supports the view already established by other evidence that, at present, no general hazard and no widespread apprehension exist in respect to aluminum-wired residential branch circuits in Ontario.

Nevertheless, even if there is little hazard now, the question has been raised that hidden dangers may exist which perhaps will recur. This seems to be the meaning of the term, used several times by one witness in Ottawa, that aluminum wiring is a "time bomb," or of another witness's phrase, that only the "tip of the iceberg" is seen. These expressions have the connotation of inevitable disaster, but perhaps after a long delay. The Commission found little evidence to support this view and much to suggest that, if problems are to occur, they are likely to appear quickly, as the following considerations show:

First, the houses wired with aluminum in Arvida were inspected after twenty-eight years and showed no evidence that the wiring systems were failing or giving trouble.

Second, the Commission was surprised at the number of witnesses who reported having experienced problems with new houses, either when they moved in or shortly afterwards. This experience indicates rapid deterioration in some cases, and in others, that poor workmanship is soon evident.

Third, the general evidence for the period from 1965 to 1976, discussed above, shows that the use of aluminum was followed within two years by a rise in problems but that, after building was reduced in 1974 and corrective actions had been taken, problems also subsided.

Fourth, several laboratory tests show that, if connections are loose, they fail after a few cycles, not after a long time.

Fifth, some technical considerations discussed in Section 2.5 suggest that, if a connection is overheating or is loose and able to oxidize, it will deteriorate and fail quickly, but that a tight connection which has made welds will hold and may even improve with time. On the other hand, other technical information suggests some possible causes of deterioration with time, and this introduces a note of caution.

In summary, some houses in which the workmanship was good have lasted a generation without trouble even though they were wired with devices and a grade of aluminum no longer approved. On the other hand, poor workmanship and improper devices could and did lead to problems but, because it seems that most of these can be, and have been, fixed, there is no urgent need for wholesale replacements. Nevertheless, where peoples' homes are concerned, even a small amount of doubt or a few possibilities for trouble deserve consideration. Appropriate steps to deal with these cases are discussed later.

*b. Variations by Region.* The Commission was impressed by the fact that, although it advertised all over Ontario and was prepared to hear evidence from witnesses from any part of the province, the only witnesses who did come forward were from the two largest cities and their surrounding areas.

Because of increasing urbanization and the rapid expansion of Toronto and Ottawa, it has been in the suburbs and surrounding areas of these cities that growth has been most rapid. This presumably led to the maximum competition for work, the greatest introduction of elements that would save time and money, the largest chance of employing inadequately trained or inferior workmen, and the heaviest loads upon inspection services. Several witnesses testified that poor workmanship in electric circuits was only one sign of shoddy construction which was also evident in other parts of their homes.

Mass production has improved many industries because identical products move along an assembly line, each product receiving identical treatment and appropriate inspections in an unvarying order. The mass production of houses on location is not done by a parallel method. No two houses, nor the land on which they are built, are the same. Construction can be delayed by weather and by a lack of supplies, workmen, or inspectors. The rush to build many units at the same time provides opportunities for negligence here or lack of supervision and full inspection there. These kinds of opportunities do not exist to the same extent when one or a few houses are constructed individually.

The evidence showed that there has been little trouble in the building of houses in Ontario, and this suggests that there is no need for wholesale changes. A few areas have reported problems and these demand special attention, which will be discussed below.

c. *Variations in Circumstances.* It is evident that the conditions at terminations play an important part in determining the relative reliability and safety of aluminum versus copper wiring.

Of all the factors, the tightness of the connection under binding-head screws seems to be the most important. Where screws have been firmly tightened with a torque of about 12 lb-in, well-made connections with both aluminum and copper last and any difference in their performance is insignificant. With loose connections, however, the properties of aluminum and its oxides are such that aluminum deteriorates more rapidly than copper.

Poor loops formed around binding-head screws and the absence of loops and nicks in the aluminum wire also decrease its reliability faster than copper.

Aluminum is also more likely to fail than copper when in contact with steel screws. These have never been authorized for use in current-carrying circuits in Ontario, but they have been in the United States. Evidence suggests that, in this respect, the Ontario practice has been safer than the American. Unfortunately, some unapproved devices were imported. Aluminum also appears to perform less reliably than copper with zinc-plated screws, now banned, and also in receptacles of the push-in type, of which one make was authorized for use with aluminum in Ontario from 1970 to 1974. Some evidence suggests that push-in connections also often overheat with copper wire.

Laboratory tests conducted in the early 1970's included removing receptacles from junction boxes and then re-inserting them. It was noticeable that failures occurred more frequently immediately after a connection had been disturbed. To disturb a connection reduces reliability, probably for copper as well as for aluminum. Wire guides moulded into devices should possibly reduce this hazard.

Aluminum appears to be more sensitive than copper to the effects of heating. Therefore, heavy loading, abuses (such as overloading, overfusing, or the addition of extra loads, particularly such cyclical ones as the unauthorized use of air conditioners on general circuits), and the addition of thermal insulation are all more likely to affect the reliability of aluminum wiring than of copper.

### **1.8.2 Factors Affecting Both Copper and Aluminum Residential Wiring**

There has been a steady increase in the loading of residential circuits for many years. Early in this century, the present system of wiring was introduced to replace the former type — called the knob-and-tube system — which used porcelain insulators. The new system was designed to carry a current of 12 amperes, but at that time the loads were light, usually only a few amperes, and the system had a higher safety factor.

More home appliances have been added throughout the years and are still being added in many homes. As a result, many circuits are operating today at close to 18 amperes part of the time. This is possible because the fuses used for the 12-ampere circuits are rated at 15 amperes, but usually only fail at 17 or 18 amperes. The flow through circuits of fifty per cent more current than the system was planned to take produces much more heating than was allowed for, and increases the chances of failure and hazard.

There is general public ignorance about home wiring. Many householders do not know whether their homes are wired with copper or aluminum. Householders take safe operation so much for granted that they may do things casually that are unsafe. The Commission heard of examples of overfusing and of the addition throughout homes of many appliances, which often draw heavy cyclic loads, without consideration being given to the desirability of increasing the number of circuits. Many who complained of troubles had connected air conditioners to bedroom general circuits, which is not an authorized practice and is an invitation to trouble.

There are many, far too many, household fires in Canada. Efforts are made, especially by fire departments, to reduce the number of these fires, but the state of public concern is such that only limited amounts of money are available to reduce the hazard. It is important, therefore, that such funds as are available be spent as efficaciously as possible.

Evidence showed that household fires have many causes, including careless smoking, children playing with matches, ignition of food and cooking fat in the kitchen, arson, chimneys catching fire, and lightning. Only a small proportion of all fires are of electric origin. In this connection, the evidence of A. Sowards seems pertinent. Mr. Sowards is a householder living in a house wired with aluminum wiring in the area of Kanata, a suburb of Ottawa. This area is in one of three or four townships of Ontario that has banned aluminum wiring because of reported problems. When the Reeve formed an Aluminum Wiring Committee, Mr. Sowards volunteered to become a member and, while giving evidence of that committee's investigation of troubles supposed to be due to aluminum wiring, stated:

. . . early in 1975 when the ban was instituted and so we were investigating the situation at that time. The March Township Fire Department was called to 82 fires, and I won't go through the breakdown of them but I have it here. There were ten for chimneys, seven for children playing with matches and so on and then we got down to three for oil heating systems and three involving electrical wiring. So, in other words, we didn't seem to be getting a very large number of fires for which we were of course very thankful. . . (Transcript Volume 16)

The Fire Marshal's reports confirm that only in the order of ten per cent or less of all fires are of electric origin. Furthermore, other evidence showed that, of fires due to electric causes, most are due to failures in appliances and in extension cords and that only a minority start in the residential wiring.

Thus, residential wiring causes only a small percentage of all fires in homes. Furthermore, only a tenth of the houses in Ontario have aluminum wiring. This means that, of all household fires, only a very small percentage are due to aluminum branch-circuit wiring. While every effort should be made to reduce these and while every fire is a disaster for those involved, nevertheless, if this one cause of fires could be completely eliminated, it would have little effect upon the total number of fires in homes. The Commission is charged with an investigation concerning aluminum residential wiring. It sees this wiring as an important, but only minor, part of the total concern that should be felt about safety and reliability of Ontario homes.

### 1.8.3 Conclusions

Bearing in mind these and other considerations, the Commission has reached the following conclusions:

Electric wiring systems were developed before the invention of any cheap method of producing aluminum. They were, therefore, all originally designed to suit the properties of copper. Because aluminum is cheaper and lighter, it has replaced copper for transmission lines, distribution systems, and in aircraft. The process of replacement produced problems which have been overcome.

In 1946 and again in 1965, copper became hard to obtain and expensive. The second shortage affected Ontario more than the first but, on both occasions, aluminum was introduced in many jurisdictions as a substitute for copper in residential branch-circuit wiring. It was not supposed that it was better, but it was available and it was cheaper. What evidence there was, based upon inadequate knowledge and experience, suggested that it was acceptable. During the second period of shortage of copper, aluminum was used widely in Ontario. The demand arose suddenly. There was no time to carry out extensive research or to devise a new system that took into account the properties of aluminum, but work on these problems was begun and has increased steadily as the need has become apparent.

It is unfortunate that, during the decade immediately after it was introduced on a large scale, aluminum should prove less reliable than copper and produce a greater number of failures than copper. The electric system, of course, is so designed that most failures are safe, although they may be disconcerting. If aluminum was less reliable during that period, it would seem logical to suppose that it was also less safe, but statistics are lacking and other evidence is uncertain about the safety aspect. However, the fact that evidence about safety is obscure is understandable: a fire (unlike a failure without a fire) is likely to destroy evidence as to its



origin; and the fires due to residential wiring form such a small percentage of the total number of fires.

Once the various problems had been recognized clearly and appropriate remedies devised, action was taken and these difficulties have now been largely resolved.

#### **1.8.4 Range of Possible Actions to Recommend**

In the light of its conclusions, the Commission has given careful thought to many different courses which it might take, and has considered which to recommend and which to ignore. The range is wide, from complete elimination of all aluminum wiring to no action at all, and includes the following possibilities:

*a. Ban of Aluminum Wiring for Residential Use.* Aluminum wiring could be totally banned for use in housing and all existing aluminum conductors replaced with copper. The cost per house would be perhaps \$800, which, for 250,000 houses, would total \$200,000,000. The citizens of Ontario ultimately would have to pay, in one way or another, an average of \$80 per household. None of the homes wired with copper would benefit, while replacement of the wiring does not appear to be needed in most aluminum-wired homes. In any case, the main difficulty lies not in the aluminum conductors themselves but in whether or not the connectors on the devices are compatible with the particular conductor.

As has been noted already, since most fires have other causes, the complete elimination of failures and fires due to aluminum wiring could at best reduce the total number of incidents and fires in houses by a small percentage. If large sums are to be spent, there are more effective ways to increase safety. This method seems to be much too wholesale and expensive, and does not seem to be a sensible approach. It is not recommended.

*b. Recall of Weak and Defective Devices.* This concept derives from the automotive industry where it works easily because each car is closely defined by its make, model, year, and even its serial number. All these are recorded on licences which are renewed annually; as a result, owners, dealers, manufacturers, and the government know very clearly with what they are dealing. If a part — for example, a transmission — is found to be dangerous, it is possible to trace all the cars with that type and have the transmissions repaired or replaced.

Houses are not standardized like cars and no records are kept of what parts go into each house. Furthermore, few drivers change any essential parts of their cars, but householders commonly add circuits and change receptacles.

Unlike cars, few of which last more than ten years, houses are expected to last for fifty years at least. Some electric devices are already known to be poor and have been banned, but because wiring, like houses, is built to last, it can be argued — especially by those who believe in the time-bomb principle — that other devices which have not yet been identified may ultimately fail. This raises the question of which parts should be recalled and replaced.

Thus, for a recall system to work, one would have to first identify all faulty devices and pieces of equipment and then, having done that, search to find them. To do this completely would require a house-to-house inspection, and a look at all devices, throughout the province. The disturbance of old wiring which this would entail would, in itself, create new failures.

In the automotive industry, manufacturers are few, well established, and easily identified. Furthermore, the same company manufactures or at least certifies the parts, assembles them, and sells the finished product. In the housing industry quite different companies manufacture the materials, act as builders, and function as electrical contractors. Some of the smaller contractors tend to go out of business. Thus it would be difficult to determine responsibility.

Finally, automobiles, once sold, are used in a fairly standard way. Receptacles in a house, on the other hand, may be used moderately, may not be used at all, or may be overloaded.

To recall defective parts or to replace aluminum wiring would not benefit those who have overcome problems by their own initiative. And these, it would seem, are numerous.

In the absence of any records, the notion that defective parts can be recalled, as in the auto-

motive industry, is not workable and is not recommended. The idea of eliminating faulty devices is excellent but will have to be tackled in a different way.

c. *Widespread Advertising of Dangers in the Home.* Since about 1975, this has been the subject of much attention in the press, on radio, on television, through householders' organizations, through a free telephone hot line by which Ontario Hydro gives free advice in the Brampton area, and by leaflets distributed by utilities. This publicity has been excellent. It has alerted home-owners to possible dangers; it has told them of danger signs; and it has led to remedial actions. This has led to a decline in reports of fresh incidents and fires. Relative to the two previous suggestions, this idea has several merits. It has already been tried and has proved effective. It is inexpensive. It serves to draw attention to other and greater sources of danger, for whether or not aluminum wiring is less reliable than copper, residential wiring constitutes an insignificant hazard in the home. The Commission is in favour of extensive publicity.

It seems to the Commission that the great increase in the variety and use of appliances is placing loads upon the electric system of residential wiring which were not envisaged when the system was designed. These loads often affect aluminum before copper, but also cause failure in copper-wired circuits.

The publicity should caution householders about the dangers of indiscriminately adding more appliances, especially cyclically operating, heavy-duty appliances, such as heaters and air conditioners of all kinds. It is safer to operate most of these appliances on separate circuits, especially in aluminum-wired homes; professional advice should be sought before they are plugged into general circuits.

The Commission is concerned about the number of fires in Ontario homes and has noted that few of them are due to aluminum wiring. It suggests that publicity should take a more positive and wider view about household dangers. The construction industry has set an example by its recent excellent television advertisements showing safety precautions. The Commission recommends that the electrical and building industries should advertise all potential dangers in houses, including electric failures, and show how these can be reduced.

d. *Free Inspection of Aluminum-Wired Homes.* Ontario Hydro has instituted the policy of providing one free inspection of any home wired with aluminum for any householder who requests the inspection and who reports indications of a problem. The Commission believes, and evidence shows, that such an inspection, coupled with a free hot line for advice and extensive advertising of danger signals, is an effective way of finding any wiring systems that are not reliable, of advising householders, and of assisting them to rectify problems. It will also serve to reassure the many householders who may be apprehensive, without cause, as a result of much publicity.

e. *Compulsory Annual Inspections of House Wiring.* The Commission also considered recommending compulsory annual inspections of all house wiring, but decided that these would be expensive and unnecessary. It does recommend a compulsory electrical inspection whenever a house is sold, to insure that possible errors and dangers are not passed on to unsuspecting purchasers. This requirement would discourage illegal and uninspected efforts at home wiring and it would enable Ontario Hydro to monitor a random selection of houses. Such a procedure would enable inspectors to determine whether or not aluminum wiring is degenerating faster than copper wiring, for it must be recognized that no wiring lasts forever and that it has to be renewed in many old houses.

f. *Ban of Wiring by Handymen.* The Commission considered a policy of banning the installation of wiring by home handymen — which has been applied in some other jurisdictions — but concluded that, with the do-it-yourself tradition that exists in Ontario, such a law would be likely to be broken and would be difficult to enforce. It seems wiser to encourage better work through advertising the existence of courses in home wiring, through free advice via the hot line, through helpful rather than punitive methods of inspection, and through the knowledge that, before a house may be sold, it must be inspected and brought up to standard.



g. *Ban of Future Use of Aluminum Wiring.* This would do nothing for existing homes wired with aluminum except considerably reduce their value. It would take away the incentive to develop better systems based on aluminum, the prospects for which look promising. It should be remembered that, during the early history of the electrical industry, all transmission lines were made of copper. Since then, the transition has been made successfully and these lines, with few exceptions, are now made of aluminum. This change involved problems and failures but has been successful and has reduced costs. Later, the same transition was made safely, after difficulties, with distribution systems and aircraft wiring. It should be possible to accomplish the same change for residential wiring. The recommended first steps are to complete and improve the CO/ALR series of devices and to introduce improved aluminum alloys. Ultimately, a system of crimp or compression connections, such as are used in the transmission lines, may be a good answer, but such a system needs considerable development to make it reliable, safe, and practical in the field. This development should be undertaken.

h. *Bounty for Unauthorized Devices.* Because it does not seem feasible to recall unauthorized devices, the Commission considered recommending that a bounty be offered to encourage householders with such devices to make them known. This does not seem practical and is not recommended. Most of the devices in question are abundantly available, since they are legal for use with copper or for sale in the United States. Most devices are very cheap, many costing less than a dollar. A bounty system, therefore, would be open to abuse and would not reach those householders who do not understand their wiring systems.

The fact is that the replacement of failed receptacles, both with copper- and aluminum-wired circuits, is common and not expensive. Testimony at the hearings suggests that most householders with problems have already solved them; free advice, free inspection, and free estimates should be offered to encourage others to do the same.

i. *Areas of Particular Problems.* The evidence shows that in Ontario, while there are large regions from which few, if any, problems have been reported, there are some districts where a concentration of problems has occurred at certain times. These appear to be due to a combination of poor workmanship, inadequate inspection, the use of unauthorized receptacles, and the use, between 1970 and 1974, of receptacles of the push-in type. Additional factors present in some cases were improper work by home handymen, overfusing, and overloading.

Fortunately, the resulting problems have been well publicized and the evidence shows that, if problems are to occur, they generally begin to appear quickly. Many inspections and much action certainly have reduced the problems greatly; in order to eliminate any hazards that may remain, a watchful policy should be continued in the future.

In any district where there have been several incidents involving the electric system in houses built at about the same time by the same builder, householders and inspectors should be sure that other householders in the district are aware of possible problems and of signs warning of trouble. This is not to suggest that problems necessarily exist in all the houses in a group. One poor workman among many can cause sporadic failures, and so can occasional mistakes, not seen during inspections, and the chance distribution of faulty receptacles.

The Commission believes that those areas where there have been the most troubles have already attracted the most attention and it recommends that this vigilance be continued.

j. *Some General Considerations.* There were three other aspects that entered into the Commission's considerations. The first aspect is concerned with the respective roles of the householders and the authorities in correcting problems associated with residential wiring. The evidence suggests that a few householders seem to take the attitude that because the authorities had allowed a poor situation to develop, the authorities should rectify it. Without discussing the merits or otherwise of this point of view, the Commission is of the opinion that it does seem as if the householder, in his or her own self-interest, should take the initiative if something appears to be wrong. The Commission recommends the establishment of a province-wide hot line and the offer of one free inspection of aluminum-wired homes in which there are problems, as a means of offering advice or reassurance to those who are apprehensive. Local utilities should make available lists of qualified contractors, who, in turn, should provide free estimates of

repairs. It is suggested that electrical contractors, electricians, and especially Ontario Hydro inspectors should be vigilant in watching for areas of such potential problems and in seeing that they are known and rectified. Householders' associations and meetings organized by township authorities have performed a useful service in this matter.

The second aspect is the fact that most householders are steadily acquiring more and more appliances. Evidence shows that many householders, even those who have installed in their homes a great number of appliances that place heavy loads on the system and frequently blow fuses, do not consider the need to add more branch circuits to handle the increased loads. Few householders give any thought to the maintenance of their wiring systems, and yet no wiring, whether aluminum or copper, is designed to last forever. As loads have increased, this aspect has become more important.

A third aspect is the fact that drawing conclusions that do not follow logically from the evidence may generate unnecessary fears among members of the public. A case in point was the recent incident in which the results of a test, designed purposely to be severe enough to cause a fire, were used to suggest that half a million aluminum-wired homes across Canada were unsafe. The extreme conditions employed in the test would never be encountered in most homes. If the public is not to be a prey to unnecessary fears, it is essential that reports concerning any topic of public safety be accurate, responsible, and not exaggerated.

## 1.9 Recommendations

This Commission of Inquiry on Aluminum Wiring, as instructed in the Order-in-Council 1029/77, makes the following recommendations on matters relating to the reliability and safety of residential electric-wiring systems in Ontario. These recommendations are repeated with explanatory text in the indicated sections of Part 2 of this report.

**Recommendation 1.** Only a small proportion of all fires in Ontario houses can be attributed in any way to failures in residential wiring, and effective action has already been taken to correct reported cases of poor workmanship and of the use of improper devices. It is recommended, therefore, that there is no need to undertake the vast expense that would be required to replace all existing residential branch-circuit aluminum wiring with copper. (Section 2.10)

**Recommendation 2.** Ontario Hydro and local utilities should inform all householders on how to recognize symptoms that warn that an electric system may be about to fail. These warning signals should be publicized widely, and Ontario Hydro should consider using television and other media for this purpose. (Section 2.10)

**Recommendation 3.** Ontario Hydro should extend its hot-line service in the Brampton area into a toll-free, province-wide telephone service to provide uniform information on all residential wiring. The existence of this advisory service and the toll-free telephone number should be given extensive publicity. (Section 2.10)

**Recommendation 4.** An Ontario Hydro inspector should make, without charge, one inspection of the wiring in residences of those householders who are in touch with Ontario Hydro or their local utilities directly or by referral from the hot line and who describe what seems to be a genuine problem or cause for concern. (Section 2.10)

**Recommendation 5.** Those householders who suspect or know of weaknesses or failures in their wiring systems should follow the advice of the Brampton home-owners' group to seek professional advice and have repairs made as necessary. (Section 2.10)

**Recommendation 6.** There may be localities where a quantity of unapproved materials or devices were installed with aluminum-wired systems and some of these may not have been replaced, or where there have been instances of bad workmanship with aluminum-wired systems and these may not have been rectified. If Ontario Hydro or local utilities know of or discover any such localities, they should insure that all householders in those areas are advised to arrange for an inspection of their electric systems — if that has not been done already — to make sure that no potential hazards remain undetected. (Section 2.10)

**Recommendation 7.** Ontario Hydro, in full consultation with the Electrical Contractors Association of Ontario, should establish and maintain in each region a list of electrical contractors who are willing and qualified to work upon and to repair residential aluminum-wiring systems. Ontario Hydro and local utilities should refer the public to these lists when inquiries are received about repairs or alterations to residential aluminum-wiring systems or when inspectors recommend that work be done. These contractors should be prepared to give free estimates of costs of proposed work. (Section 2.10)

**Recommendation 8.** Ontario Hydro and the Canadian Standards Association should continue to investigate panelboards and the failures reported in them and to inform inspectors, the public, and the manufacturers of any corrective action considered necessary. (Section 2.10)

**Recommendation 9.** Aluminum wiring should continue to be authorized for use in residential branch-circuit wiring of homes built in the future in Ontario. (Section 2.11)

**Recommendation 10.** The Canadian Standards Association and Ontario Hydro should authorize only aluminum-alloy conductor material or its equivalent, instead of EC-grade aluminum, for use in residential branch-circuit wiring in Ontario. (Section 2.11)

**Recommendation 11.** The Canadian Standards Association should review the provisional specifications of CO/ALR devices and develop comprehensive specifications for all devices used in a complete system of residential branch-circuit wiring. Ontario Hydro should insure that devices complying with such specifications are available in Ontario. (Section 2.11)

**Recommendation 12.** Ontario Hydro should require all builders of new dwelling units to supply the purchaser of a unit with a wiring diagram of the unit's branch circuits, the location of the various outlets, and their connections to the panelboard. The diagram should also include the authorized rating of each fuse or circuit breaker, the type of fuse recommended (whether ordinary or time-delay), the type of wiring (whether aluminum or copper), the name of the electrical contractor, the name of the Ontario Hydro inspector, and the date of the final inspection. (Section 2.11)

**Recommendation 13.** As soon as possible, Ontario Hydro and the Canadian Standards Association should organize, in the light of present and predicted loads, a complete re-appraisal of existing residential electric systems wired with either copper or aluminum. Such re-appraisal should include conductors, devices, equipment, and installation practices. (Section 2.12)

**Recommendation 14.** Ontario Hydro and the Canadian Standards Association should give greater emphasis to the reliability of residential wiring systems, in addition to their safety, when setting standards and codes of practice. (Section 2.12)

**Recommendation 15.** It is recommended that laboratory tests and evaluation procedures for establishing the reliability of wiring devices, equipment, and systems should be developed by Ontario Hydro and the Canadian Standards Association as soon as possible. Due account should be taken of field experience in Ontario dwelling units. (Section 2.12)

**Recommendation 16.** Ontario Hydro and the Canadian Standards Association should consider developing a new system for residential branch-circuit wiring. The use of aluminum conductors should be considered and attention given to determining whether copper and aluminum could be made interchangeable in the system and, if so, under what conditions. The system should be designed for reliability as well as for safety with the heavier loads now in use. (Section 2.12)

**Recommendation 17.** The Canadian Standards Association, Ontario Hydro, representatives of the electrical manufacturing and contracting industries, and others concerned should undertake, through existing committees, the necessary steps to consider modifications to currently available crimped connections. Their overall suitability and acceptability for residential circuits should be evaluated, in an endeavour to develop a system of crimped connections which might form a part of a new system of residential aluminum wiring. Preferably the system should be readily adaptable to either copper or aluminum conductors. (Section 2.12)

**Recommendation 18.** The Electrical and Electronic Manufacturers Association of Canada, Canadian Electrical Association, and Electrical Contractors Association of Ontario should financially assist the Standards Division of Canadian Standards Association to:

1. Carry out or commission independent investigations and appraisals of residential wiring systems, particularly when major or significant technological changes are imminent in the components comprising the system or in the installation practices.
2. Carry out or commission exploratory research to supplement the data provided by the manufacturers, in support of proposed or existing standards.
3. Facilitate greater participation by representatives of consumers and by the members of the scientific and technical community, particularly those not directly associated with the manufacturing or contracting industry, in the preparation of standards dealing with the reliability and safety in residential wiring systems. (Section 2.12)



**Recommendation 19.** Future revision of the Electrical Safety Code should incorporate either a design requirement that will make possible easy inspection of the tightness of binding-head screws, or a test for determining the tightness of these screws at the time of inspection. (Section 2.13)

**Recommendation 20.** Ontario Hydro should develop a comprehensive systems approach to electric inspection, which should be codified as a regulation under the Electrical Safety Code. Such an approach to inspection should give due regard to the following:

1. That the Electrical Safety Code is not violated, particularly with respect to maximum-permissible circuit impedances.
2. That specific techniques are developed to check the workmanship of installation.
3. That specific techniques are developed to check that the overall wiring is designed adequately for present-day usage and for coping with developing household electric needs.
4. That the wiring diagram (see Recommendation 12) should be checked for accuracy.

(Section 2.13)

**Recommendation 21.** The initial training period for new inspectors should be extended to include a more comprehensive review of the Electrical Safety Code and the inspection procedures necessary to detect violations of provisions of the Code. A programme of periodic updating should be instituted for all inspectors to insure that they are familiar with technological and technical changes in the industry and with changes in the Electrical Safety Code requirements. (Section 2.13)

**Recommendation 22.** Consideration should be given to the possibility of transferring additional inspectors to regions where there is an excess of work and to insuring that inspectors operate in a uniform manner throughout the province. Some strengthening of the position of the Manager of the Electrical Inspection Department of Ontario Hydro should be considered. (Section 2.13)

**Recommendation 23.** When a new edition of the Electrical Safety Code is adopted by the Government of Ontario, Ontario Hydro should insure that Electrical Bulletins that have not been withdrawn or superseded be incorporated into the new edition of the Code. (Section 2.13)

**Recommendation 24.** The Ontario Power Corporation Act should be amended to extend to two years (instead of six months) Ontario Hydro's powers to demand corrective action when a particular installation does not meet the Electrical Safety Code requirements. (Section 2.13)

**Recommendation 25.** The inspection records of Ontario Hydro should be retained for a period of ten years after the final inspection of a particular installation has been completed. (Section 2.13)

**Recommendation 26.** There should be a requirement that, at the time that a residential building is resold, Ontario Hydro inspect the electric system before the local electrical utility transfers the electric service to the new owners. (Section 2.13)

**Recommendation 27.** Ontario Hydro and Canadian Standards Association should jointly improve their system of checking that unapproved electric equipment and devices are not being sold or installed in Ontario. (Section 2.13)

**Recommendation 28.** Ontario Hydro should have injunctive power to prevent the sale and distribution and to order removal of unapproved electric equipment and devices from distributors' shelves. (Section 2.13)

**Recommendation 29.** The Electrical and Electronic Manufacturers Association of Canada, the Canadian Standards Association, and Ontario Hydro should insure that the retailer provide the purchaser of a device or component with full information from the manufacturers, on either the device or the package in which a device is sold by the retailer, or that the information is prominently displayed beside the bins at the point of sale. (Section 2.13)

**Recommendation 30.** The Ontario New Home Warranties Plan Act, 1976 should be amended to provide that the electric system is a major component of the home and therefore should be

covered by the five-year warranty period. Notwithstanding the difficulties inherent in making a warranty system effective, the Government of Ontario is urged to consider the establishment of a more comprehensive system of home warranties. Any such warranty should cover the residential wiring system for a period of five years. (Section 2.14)

**Recommendation 31.** Warranties need not be applied retroactively, but the Government of Ontario should insure that a programme of public education is undertaken. The programme would include the distribution of information advising the owner of a home wired with aluminum to consider having the electric system inspected for defects in material and workmanship. (See also Recommendation 41). (Section 2.14)

**Recommendation 32.** The Ontario building industry should establish a fund to underwrite unsatisfied claims against the above warranties. (Section 2.14)

**Recommendation 33.** Consideration should be given to amending the curriculum prepared by the Ministry of Colleges and Universities, under the provisions of the Apprenticeship and Tradesmen's Qualifications Act, to include instruction in proper installation requirements for aluminum, as well as for copper, residential wiring systems. Differences in properties and behaviour of the two metals should be stressed and the necessity for good workmanship in aluminum-wired circuits emphasized. (Section 2.15)

**Recommendation 34.** Consideration should be given to including questions on the comprehensive examination to insure that the tradesman has an adequate knowledge of the techniques required to install aluminum wire. It is recognized that the basic installation techniques are similar for both copper and aluminum wire, but the apparent need for greater care during the installation of aluminum wire makes it desirable that all electricians have an understanding of the differences in the use of the two materials. (Section 2.15)

**Recommendation 35.** A programme of training for practising electricians in the use of aluminum wire for residential circuits is impractical and unnecessary. The trade can be adequately informed of installation requirements of aluminum wire by notification of Electrical Safety Code provisions. (Section 2.15)

**Recommendation 36.** In addition to the existing powers, Ontario Hydro should be given the power to require that the builder or electrical contractor remove all unapproved equipment or materials. Where there is a failure to comply with a notice to remove within a reasonable time, Ontario Hydro should have the authority to remove and replace the equipment at the expense of the builder or electrical contractor. The limitation period should extend for two years after the initial occupation of the home. (Section 2.16)

**Recommendation 37.** The Ontario Fire Marshal's Office should review with all fire departments in the province and other appropriate agencies, methods of recording the details of electric fires and incidents to insure that reports are complete and uniform. Reports should always state whether copper or aluminum wiring or both were used in the branch circuits, regardless of whether or not the wiring is regarded as a contributing factor. (Section 2.17)

**Recommendation 38.** The Ontario Fire Marshal's Office and Ontario Hydro should establish a procedure whereby all local fire departments call an inspector from Ontario Hydro to the scene of any fire suspected to be of electric origin. (Section 2.17)

**Recommendation 39.** Ontario Hydro, in conjunction with the Canadian Standards Association, should improve and enhance their systems of information collection and retrieval. These systems should include field data on the reliability and safety of aluminum- and copper-wired dwelling units. Inspection, re-inspection, and electric-incident and -fire reports could form the bases of the revised information-gathering system.

Ontario Hydro and Canadian Standards Association should consider which parts of this material would be useful to the public and establish means of disseminating useful information. (Section 2.17)



**Recommendation 40.** The Standards Council of Canada should be informed of the findings of this Commission. (Section 2.18)

**Recommendation 41.** Ontario Hydro, in conjunction with the Canadian Standards Association, local electrical utilities, the Electrical and Electronic Manufacturers Association of Canada, and the Electrical Contractors Association of Ontario should develop a programme of public education on safety of electric installations in homes. These organizations should endeavour to interest the building industry in the extension of this programme to cover all aspects of home safety. (Section 2.19)

**Recommendation 42.** The findings of this Commission, since they are based upon a thorough inquiry among all those concerned with electrical safety in Ontario, should be publicized widely through the general and technical press, and by the radio and television stations. (Section 2.19)

**Recommendation 43.** The Government of Ontario, through its Ministries of Housing, Consumer and Commercial Relations, Energy, and Attorney General, should review the residential aluminum-wiring situation in Ontario not later than 1983. (Section 2.20)





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